

Geophysical Research Abstracts
Vol. 18, EGU2016-17748, 2016
EGU General Assembly 2016
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New homogenized daily lake surface water temperature data of three decades from multiple sensors confirm warming of large sub-alpine lake Garda

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Availability of remotely sensed multi-spectral images from the early eighties covering three decades of voluminous data could help researchers to study the change dynamics in bio-physical characteristics of land and water. However it is very important to homogenize these data originating from multiple sources which follow different standards and quality. In this study, we explored the thermal dynamics of a large sub-alpine lake Garda over last twentyeight years (1986 - 2014) using Lake Surface Water Temperature (LSWT) derived from the thermal bands of moderate resolution sensors – AVHRR/2, AVHRR/3, ATSR1, ATSR2, A(A)TSR and MODIS aboard multiple satellites. We developed a homogenized daily LSWT dataset (12:00 P.M) at 1km spatial resolution combining the data from these sensors using split window technique and performing an acquisition time correction. The gaps in the temporal database due to clouds were filled by applying Harmonic ANalysis of Time Series (HANTS). The results show high correlation ($R^2 > 90$) between satellite derived LSWT (taken into account both individual sensors and the combined data) and the in-situ data. The time correction enable us to perform a trend analysis on unified datasets corrected for its acquisition times. The trend analysis using non-parametric tests shows significant warming in annual trend at the rate of 0.01K yr^{-1} ($p < 0.05$), while in summer the increasing trend is 0.02K yr^{-1} ($p < 0.1$). The results are in line with similar findings on warming of Alpine lakes. Moreover, the advantage of the spatial coverage at 1 km resolution we are able to characterize the thermal dynamics of the lake Garda at multiple locations of this large lake.